



FUEL POVERTY AS A DETERMINANT IN ENERGY RETROFITTING ACTIONS

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ABSTRACT

Fuel poverty can be defined as "the inability to afford adequate warmth in the home" and it is the result of the combination of three items: low household income, housing lack of energy efficiency and high energy bills. Although it affects a growing number of households within the European Union only some countries have an official definition for it. In 2013, the European Parliament claimed the Commission and Estate Members to develop different policies in order to fight household energy vulnerability.

The importance of tackling fuel poverty is based on the critical consequences it has for human health living below certain temperatures. In Spain some advances have been made in this field but main existing studies remain at the statistical level and do not deepen the understanding of the problem from the perspective of dwelling indoor habitability conditions. What is more, this concept is yet to be officially defined.

This paper presents the evaluation of fuel poverty in a building block of social housing located in the centre of Zaragoza and how this issue determined the strategies implemented in the energy retrofitting intervention project. At a first step, fuel poverty was appraised through the exploration of indoor thermal conditions. The adaptive thermal comfort (UNE-EN 15251:2008) method was used to establish the appropriate indoor temperatures and consequently to determine what can be called 'comfort gap'. Results were collated and verified with energy bills collection and a survey work that gathered data from neighbours. All this permitted pointing out those households more in need.

Results from the social analysis combined with the evaluation of the building thermal performance determined the intervention. The renovation project was aimed at the implementation of passive strategies that improve households thermal comfort in order to alleviate households fuel poverty situation.

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Keywords: fuel poverty, energy retrofitting, social housing, Zaragoza, adaptive comfort model.

1 INTRODUCTION

Fuel poverty can be defined as "the inability to afford adequate warmth in the home" [1] and it is the result of the combination of three factors: household income, housing lack of energy efficiency and high energy bills.

According to recent studies of fuel poverty in Spain 17% of households spend more than the 10% of their income in energy bills. Furthermore, for the same year, results indicate that 18% of household declared being unable to pay to keep home adequately warm, 6% declared arrears in utility bills within last 12 months and 12% had leaking roof, damp walls or rotten windows in their dwellings [2].

Known the high vulnerability of Spanish households towards fuel poverty and given the important role that energy retrofitting plays in it, there is an urgent need to develop the

appropriate method to evaluate household situations in order to implement the required strategies.

In view of the above, the aim of the present research is to appraise fuel poverty conditions of households living in a social rent building block in Zaragoza in order to delimitate the appropriate retrofitting strategies to refurbish it.

2 METHODS AND MATERIALS

2.1 Building block in Zaragoza

The case study is a building block owned by 'Sociedad Municipal Zaragoza Vivienda' built in the early 90's. Located in the centre of the city, it is part of a doubled block complex separated by a large courtyard. It contains 18 social rent dwellings distributed into three storeys with six dwellings each and has two main facades facing North and South (Figure 1).



Figure 1. (From left to right) Location of the building, main facade and main dwelling floor plan.

Building envelope thermal conditions are shown in Table 1. The heating system consists of old electric radiators.

Envelope	External walls	Pitched roof	Floor under pitched roof	Floors	Windows
U-value [W/m²K]	0,47	2,62	0,64	1,03	3,2

Table 1. Building envelope thermal characteristics

2.2 Dynamic thermal simulation: comfort analysis

The building was modelled and evaluated with Energy Plus 7.0 and for that purpose Zaragoza weather data from Meteonorm [3] was used. A free running simulation was carried out in order to obtain dwelling indoor temperature evolution. Operational conditions, internal thermal loads as well as ventilation rates, were set up according to those fixed in current normative software values [4].

Adaptive thermal comfort model developed by Fergus Nicol [5] and collected in EN 15251 [6] was implemented in order to evaluate indoor thermal comfort.

$$T_c = 0.33T_{rm} + 18.8$$

The previous day temperature is gathered in the running mean outdoor temperature (T_{rm}) and can be estimated with the approximate calculation method within the EN 15251 standard:

$$T_{rm} = (T_{od-1} + 0.8T_{od-2} + 0.6T_{od-3} + 0.5T_{od-4} + 0.4T_{od-5} + 0.3T_{od-6} + 0.2T_{od-7})/3.8$$

Besides that, according to individuals' expectations the standard suggests an acceptable comfort range of $\pm 2K$ (category I) for spaces occupied by persons with special requirements

like handicapped, sick, very young children and elderly persons and of $\pm 3K$ (category II) for new buildings and renovations.

The assessment of long term general thermal conditions and the intensity of this out of range was done through the degree hours criteria gathered in Annex F of EN 15251 taking into account indoor operative temperatures.

2.3 Comfort survey work

In collaboration with Zaragoza Vivienda social services a household survey was carried out. Families were asked about their comfort conditions, energy improvement priorities and their ability to afford energy bills costs as well as the characteristics of the family members: age and health conditions.

2.4 Household prioritization and energy retrofitting works design

Both modelling and survey results were compared and household fuel poverty conditions were established. Furthermore, families more in need were pointed out. Derived from these results energy retrofitting strategies were set out.

3 RESULTS

3.1 Fuel poverty household conditions

Energy modelling and main survey results, plotted in Figure 2, show firstly the lack of comfort in dwellings as well as the existing differences on indoor thermal conditions among them. The 33% of households affirmed experiencing uncomfortable temperatures in winter, barely the same percentage that declared high temperatures in summer, the 28%. In addition, almost the 39% argued not being able to afford adequate warmth.

According to energy modelling, households suffering from worst winter conditions resulted those facing North with an average difference of the 13% of hours out of comfort. In line with that, third and first floor dwellings had 7% more hours out of comfort. To add more, even though summer conditions are not as severe as winter ones, the number of comfort hours differed among dwellings as well. Main found contrasts were related to orientation (worst conditions in South facade dwellings) and storey (44% more of overheating hours in third floor dwellings).

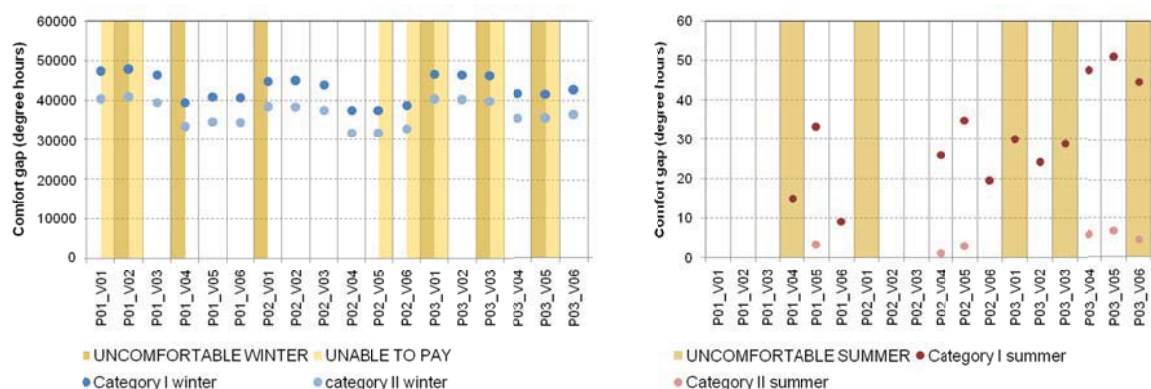


Figure 2. Winter dwelling conditions (left). Summer dwelling conditions (right).

3.2 Energy retrofitting strategies design

The most efficient strategies were established through the a climatic and energy demand study [7]. Nevertheless, the existence of fuel poverty among building households, made it mandatory to implement those strategies focused on improving indoor thermal comfort without needing any active system.

For that purpose the next strategies were selected in order to achieve a better passive thermal performance of the dwellings: insulation addition in walls, roof and floors, window glass changing and solar protections in South facade. Besides that, in order to decrease electricity demand and consumption, a hybrid solar system was proposed for DHW and electricity generation, solar tubes for courtyards and presence detectors for common spaces. Household electricity contracts were revised and the contracted capacity was cut down. Finally, green surfaces and shading elements were designed for the main courtyard so as to help microclimate conditions.

4 DISCUSSION

Within this research it was stated the importance of taking into account not only the energy performance improvement capacities of the building but the socioeconomic characteristics of householders living in the building. These considerations must guide the decision making and determine the most suitable intervention.

In those cases in which households undergo fuel poverty, it is essential the improvement of the building passive performance by means of easy solutions with minimum use and maintenance costs.

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